Animated *AUDITORY DEMONSTRATIONS II*

Challenges in Speech Communication and Music Listening

Distributed by the Acoustical Testing Laboratory
NASA Glenn Research Center
http://acousticaltest.grc.nasa.gov

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Introduction

Noise affects our lives in many different situations. At high sound levels, ongoing exposure can lead to noise-induced hearing loss. Even at low levels some sounds can cause annoyance or distraction. Within this continuum lies a vast range of experiences that encompass most of our daily lives including workplaces, vehicles, restaurants, etc., where the chief noise complaint is usually difficulty in understanding speech. The difficulty only increases when the environment is highly reverberant and/or the listener has hearing loss.

The NASA Glenn Research Center Acoustical Testing Laboratory has produced this collection of short animated video demonstrations to illustrate the impact of acoustical conditions and hearing loss on everyday listening situations, including the enjoyment of various styles of music. This collection consists of visually animated versions of selected audio tracks from NASA's audio CD ***Auditory Demonstrations II: Challenges in Speech Communication and Music Listening.*** Each animated video demonstration on this disc provides a visual roadmap that allows the listener to easily identify audible but subtle changes in the audio signal, along with the numerical metrics that quantify the changing technical parameters. These visual cues eliminate the need for the presenter to speak while playing a demonstration, which, ironically, masks the very changes that are being signaled. Furthermore, some audio demonstrations incorporate the effects of multiple parameters that cannot be tracked effectively without an animated visual aid.

This CD is a stand-alone product. For the demonstrations from ***Auditory Demonstrations II*** that have been included, it is a self-contained resource, complete with full content of the liner notes from ***Auditory Demonstrations II***. Table 1 provides a cross reference between the animated video demonstrations included in this collection and the audio demonstrations in ***Auditory Demonstrations II***. Track numbers in red bolded parentheses refer to the tracks that are included on this Animated ***Auditory Demonstrations II*** CD. For instance, track 3 on this Animated ***Auditory Demonstrations II*** CD is an animated version of the audio demonstration of speech with increasing Noise Criterion (NC) sequence that is track 5 on ***Auditory Demonstrations II.***

Table 1

Matrix of auditory demonstrations by track number

Auditory Demonstrations II (audio CD) track number cross referenced with

(Animated ***Auditory Demonstrations II*** **track number)**

	Interior ambient noise*	Intruding ambient noise	Hearing loss	Hearing protectors	Reverberation
Spacecraft	4,5**(3)**,6		7,8		
Automobile	9		10		
Restaurant	12		13**(4)**		
Meeting room	17**(6)**	15,16**(5)**			18**(7)**
Classroom	21	20,21**(8)**			21
Aircraft	23		24		
Industrial	26		27**(10)**, 29-32	28**(11)**, 29, 30, 31, 32	
Music			35-44**(12-21)**		

*Could include sequence of NC backgrounds, typical interior environmental sounds, or competing conversations.

The audio demonstration tracks from ***Auditory Demonstrations II*** for which animated video demonstrations have been included in this collection are those that illustrate the most basic concepts in each category. It is hoped that an animated demonstration will introduce the audience to a particular concept in such a way that it will be easier to listen to the additional audio demonstrations in a category (e.g., those included only as audio demonstrations on ***Auditory Demonstrations II)***, if desired, without the benefit of visuals. Alternately, the animated video demonstrations may provide ideas for creating simple visuals to accompany the audio demonstrations not included in this collection.

How to use this CD

This CD is intended to be used as a training and advocacy tool for stakeholders in the hearing conservation and low-noise design communities who have a need for technically credible and entertaining demonstrations of the experiential effect of various design parameters and other design decisions. Training and advocacy presentations are commonly developed and delivered in a PowerPoint® format. Therefore, the animated video demonstrations in this collection have been linked into a PowerPoint® template presentation. The user may customize this presentation for each audience as needed. The animated video demonstrations, each approximately a minute in length, may be used as part of this PowerPoint® presentation, incorporated into any other PowerPoint® presentation, or run independently using Windows Media® Player on the Windows® platform or QuickTime® on the Macintosh® platform.

In order to optimize the quality of the video animations, separate versions have been created for Macintosh® and Windows® platforms. The content of the Animated ***Auditory Demonstrations II*** CD is organized into two folders, “Windows” and “Macintosh.” Within each of these folders are all of the files pertaining to the subject operating system. Subsequent discussion in this document that refers to particular files should be assumed to refer to those files that are located in the folder corresponding to the user’s specific platform.

The contents of each platform folder are as follows:

- Readme.txt (important instructions)
- Animated_Demo_II_Template.ppt (PowerPoint® template presentation)
- Animated_Demo_II_Booklet.pdf (electronic version of this document)
- 1cal_speech (audio only)
- 2cal_tone_tracks_3-8 (audio only)
- 3speech_ISS_NC
- 4speech_restaurant_NIHL
- 5speech_STC
- 6speech_NC
- 7speech_reverb
- 8speech_multiple
- 9cal_tone_tracks_10-11 (audio only)
- 10speech_industrial_NIHL
- 11speech_NRR
- 12music_pop
- 13music_rap
- 14music_rock
- 15music_country
- 16music_latin
- 17music_techno
- 18music_jazz
- 19music_classical
- 20music_big_band
- 21music_swing

Within the PowerPoint® template file, each animated video demonstration slide is preceded by an introductory slide. The format of the introductory slides is intended to provide, in a standard format, key

information that the presenter ought to mention prior to showing the animated video demonstration on the following slide. For the communication demonstrations (tracks 3 to 8 and 10 to 11), this includes the following items:

- General nature of the demonstration
- Track number of the animated video demonstration on this Animated ***Auditory Demonstrations II*** CD
- Description of the signal (e.g., lecture hall speech)
- Description of the venue (e.g., lecture hall)
- Challenge(s) to the signal (e.g., background noise sequence)
- Parameter that is changing during the sequence (e.g., NC)
- Significance of the audible beeps in the sequence (e.g., five-point increment in NC)

The presenter may wish to make use of the introductory slides as part of the presentation or to use only parts of the information in conjunction with the animated video demonstration slides. This slide-pairing concept gives the user the flexibility to customize the presentation. In addition, the user may make use of the slide masters to create new slides with original content that is specific to the user's message.

The PowerPoint® template presentation is organized to help the user interactively browse the animated video demonstrations by means of menus that hyperlink to the various pairs of introductory and demonstration slides. When customizing the PowerPoint® template for a particular presentation, these menus, as well as any animated video demonstration and introductory slides that will not be used, may be deleted. *Please note that if you delete slides, some of the hyperlinks may no longer work. Also, the PowerPoint® template is best viewed in PowerPoint® 2003 or later version. In earlier versions, the slide design may not appear properly, and some aspects of the animation of linked files may not work.*

It is suggested that the credits slide at the end of the PowerPoint® template presentation be used at the conclusion of a presentation to identify the source of the animated video demonstrations and to communicate the availability of single copies of the Animated ***Auditory Demonstrations II*** CD via the online request form on the ATL Web site (http://acousticaltest.grc.nasa.gov).

Note: To customize the template presentation, you must first drag the entire folder corresponding to your operating system (Windows® or Macintosh®) to your hard drive. You may rename the presentation, but do not rename any of the linked animated video demonstration files. Do not remove the animated video demonstration files from the folder or transfer any of the files separately, since the hyperlinks between the PowerPoint® template presentation and the animated video demonstration files will be broken if the linked files are not maintained in the same folder with the PowerPoint® file.

As an alternative to using the PowerPoint® template presentation, the animated video demonstrations may be incorporated into any PowerPoint® presentation by following the program's menu-driven commands: Insert>Movies and Sounds>Movie from File and then using the browser window that appears to select and link the desired animated video demonstration from the CD or from your hard drive, which is the preferred method of linking the animated video demonstrations for optimum system display performance.

Calibrating the output sound level

Three audio calibration tracks are included on this CD to provide a means of calibrating the playback level of the animated video demonstrations so that the sound level in the presentation space is as accurate as possible and so that the full dynamic range of each demonstration is audible. Track 1 contains an unfiltered conversational vignette that may be used to calibrate without a sound level meter by adjusting the volume of the playback system to a comfortable listening level. Track 2 contains a calibration tone (70 dB centered at 1 kHz) for use with a sound level meter. These tracks are to be used with the animated video demonstrations on tracks 3 to 8. There is a different calibration tone (also 70 dB centered at 1 kHz) on track 9 that is to be used prior to playing tracks 10 and 11. Since these two tracks involve typically

louder sounds, the calibration signal is recorded at a lower level so that the volume of the playback system will have to be increased substantially. For the music “meltdown” tracks (12 to 21), adjust the volume to a comfortable listening level that is clearly audible throughout the track. Note that the volume will drop as the hearing loss simulation sequence progresses.

About *Auditory Demonstrations II: Challenges in Speech Communication and Music Listening*

The animated video demonstrations on this Animated ***Auditory Demonstrations II*** CD were created from selected audio demonstrations taken from the collection, ***Auditory Demonstrations II: Challenges in Speech Communication and Music Listening,*** produced in 2004 by the Glenn Research Center Acoustical Testing Laboratory. The audio demonstrations in the original ***Auditory Demonstrations II*** collection illustrate both the need for and the benefits of noise control efforts in a wide range of situations where good speech intelligibility is desirable. In addition, recordings of several styles of music were modified to demonstrate auditory changes due to progressive noise-related hearing loss. The audio demonstrations were intended as tools with which engineers, designers, architects, policymakers, and others could experience and tangibly gauge the true cost of communication interference due to various challenges to speech communication, such as noise and hearing loss. The challenges may be presented singly or in combination and are often most effective when presented as a series of progressive steps, demonstrating a single challenge before combining it with another.
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It is more difficult to motivate noise control efforts for the sake of speech intelligibility than for hearing conservation because it is generally perceived that noise interference with speech is merely an inconvenience. Furthermore, it is easy to adopt a variety of coping mechanisms, such as speaking up and moving nearer to the speaker. However, these mechanisms may not be practical or sustainable in some communication situations.

The audio demonstrations in ***Auditory Demonstrations II*** and the animated video versions in this collection place the listener in the middle of challenging real-life situations without recourse to these coping mechanisms. While these demonstrations might appear to be artificially restricted to a given listening situation, the demonstrations have been carefully constructed to represent appropriate sound levels from participants in actual conversations, with corresponding acoustical conditions.

For more information about the complete collection of audio demonstrations included on the ***Auditory Demonstrations II: Challenges in Speech Communication and Music Listening*** CD, including the full text of the liner notes, please visit the NASA Glenn Research Center Acoustical Testing Laboratory Web site at http://acousticaltest.grc.nasa.gov.

Description of Speech Communication Demonstrations

The animated video demonstrations on this CD and the original audio demonstrations on the ***Auditory Demonstrations II*** cast the listener as a third-party listener to a situation-appropriate conversation in the arbitrarily chosen environments of interest, including spacecraft interiors, lecture halls, restaurants, classrooms, and industrial facilities. The scripts are intended to be compelling and entertaining, so that loss of speech intelligibility can be expected to create a sense of frustration. The speakers do not raise or lower their voices, nor do they move relative to the listener. As a result, the inability to adapt to the situation dramatically highlights the need for noise control.

Ambient sounds native to a number of environments are presented at appropriate levels. They are presented singly or in sequence, usually from best to worst speech intelligibility. For tracks 3, 6, and 8, broadband noise has been synthesized to match NC curves. NC values are tabulated in appendix A. In tracks 5 and 8, sounds intruding into the listening space are filtered to simulate performance of various partitions ranging from Sound Transmission Class (STC) 20 to 60.[1] Insertion Loss (IL) of various wall panel constructions is tabulated in appendix C.

On most tracks, the listener is assumed to have no hearing loss. The audio signals on tracks 4 and 10 as well as on tracks 12 to 21 are filtered so that a normal-hearing person can experience hearing loss that might be predicted (based on ISO 1999) for exposure to 90 dBA (unprotected or at the ear) for 8 hours per day over a period of years.[2] ISO 1999 predicted hearing loss values are tabulated in appendix B.

The audio signal on track 11 is filtered to simulate use of hearing protectors with rated attenuation ranging from Noise Reduction Rating (NRR) 12 to 29.[3] Typical attenuation data for hearing protectors with various NRR values is tabulated in appendix D.

Finally, on tracks 7 and 8, digital reverberation has been added to increase realism and to demonstrate the effects of reverberation on speech intelligibility.

About the visual component of the animated video demonstrations

Each of the animated video demonstrations on this CD incorporates an audio track from the ***Auditory Demonstrations II*** CD, minus the narrator's introductory remarks. An animated visual component with a standardized format has been added to each of those audio tracks. This provides a means of tracking the changes in the audio signal in real time and relating the auditory change to specific numeric metrics. In each animated video demonstration, an animated graphical display includes the spectrum of the parameter that is changing as well as the corresponding single-number metric, using the following format:

- Animated background imagery depicts the venue, action, and/or context associated with the conversation taking place in the audio signal. In the communication demonstrations, the background imagery consists of character still images that have been animated to humorously approximate what might have been captured if video signals, rather than audio signals, had been recorded during the creation of the original ***Auditory Demonstrations II*** CD. In the music demonstrations, this imagery serves only to provide a style context for the particular music selection.
- An animated graphical display in the upper left-hand corner of the screen represents the range of spectra of the single parameter that is being varied in the audio signal. As each successive value of the parameter is reflected in the audio signal, the corresponding spectrum is illuminated.
- A continuum of values of the single-number metric associated with the subject parameter is displayed across the top of the animation frame. As each successive value of the parameter is presented in the audio signal, the corresponding single-number metric is illuminated.

The only exceptions to the above format are track 7 (reverberation time) for which there is no meaningful spectral display and track 8 in which multiple parameters are changing simultaneously. The visual component of the animation in track 8 includes a multiparameter timeline rather than graphical plots of the spectral characteristics of individual parameters. It is assumed that the user will have introduced the audience to the individual parameters (NC, STC, reverberation time) using tracks 3 and/or 6, 5, and 7 prior to demonstrating the combined effects with track 8.

Conveying "appropriate" values for demonstrated parameters

The background imagery for the animated communication demonstrations serves to provide a context for each conversation vignette. In some tracks, particularly the music tracks, it merely provides visual interest while the graphical and single-number metric displays convey the bulk of the information content of the demonstration. In tracks 3, 5, and 7, which simulate a range of NC and reverberation time values, the background imagery is used to convey the appropriateness of the value of the acoustical parameter being simulated for the specific activity being depicted. Recommended[1] design values of NC and reverberation time for various spaces are simulated in the audio track and paired with images of those spaces as the value of the acoustical parameter moves through a sequence of values. The "conversation" continues as the primary character(s) is seen sequentially "visiting" each space in the presence of the corresponding acoustical challenge. It is intended that the juxtaposition of the nature and content of the conversation against each of the venues in which it is shown will illuminate the relative appropriateness of the space

(and the design value of the acoustical parameter) for the activity surrounding the conversation. For instance, in track 6 a speaker is heard delivering the welcoming address at a professional society conference while shown moving through a series of venues with typical NC values, from a bedroom to a mechanical room. The message conveyed by this visual component of the demonstration is intended to reinforce the auditory experience of listening to the speaker deliver his remarks in background noise levels that are typically associated with, and are appropriate for, various spaces other than a lecture hall.

In track 3, which illustrates a conversation taking place on the International Space Station, a series of spaces that are appropriately associated with a sequence of background NC levels is viewed from the exterior (e.g., from "space") in order reinforce the impression that the conversation is taking place on the International Space Station.

In track 5, which depicts the effects of a wall partition with an ascending series of STC values, the background imagery has an additional element. A speaker is shown delivering an address while a sales rally is taking place on the other side of the wall. As the simulated STC of the wall partition increases, the symbolic noise attenuating performance of the partition is conveyed by the morphing of a less dense image of the wall to one that is nearly opaque.

Description of Animated Music Listening Demonstrations

Each of the animated video demonstrations on this CD that simulate music listening with progressive sensorineural hearing loss uses a single passage of music, drawn from one of many popular styles, which has been sequentially filtered to more accurately reflect hearing loss characteristics drawn from ISO 1999. The filters are generated with median hearing loss values (which include hearing loss due to aging) for an unscreened population exposed for 8 hours per day to 90 dBA (unprotected or at the ear) for 0, 5, 10,…40 years. Musical selections are filtered to simulate 5-year exposure increments, with each 5-year increment indicated by a beep. The music is still audible and for the most part intelligible, although certainly far less enjoyable. The filter reverts to the acoustic characteristics of the "0 year case" at the end of each presentation.

The background imagery for the animated music demonstrations provides a style context for each music selection for the purpose of adding visual interest. In addition, an animated display includes the spectrum of the ISO 1999 hearing loss predictions and the number of years of exposure (see appendix B). This provides a means of visually tracking the changes in the audio signal and relating the auditory change to numerical metrics.

Music listening demonstrations included on this and the original ***Auditory Demonstrations II*** CD include the following styles of music: Pop, Rap, Rock, Country, Latin, Techno, Jazz, Classical, Big Band, and Swing.

Credits

Project Management	Beth Cooper *NASA Glenn*
Flash Animations and Packaging	Nicholas Hawes *Cleveland Institute of Art*
Music Animations and Video Compositing PowerPoint® Template Design	Eric Mindek *RS Information Systems, Inc./NASA Glenn, LTID*
Photography	Marvin Smith *RS Information Systems, Inc /NASA Glenn, LTID*
Video Encoding and Disc Programming	Emery Adanich *RS Information Systems, Inc./NASA Glenn, LTID*

Technical Sound Design	David Nelson, *INCE.Bd.Cert.* *Nelson Acoustics, Elgin, TX*
Recording Studio*	Tequila Mockingbird *Austin, TX*

Video** Characters

Track 4	Nicholas Hawes, *Cleveland Institute of Art* Barbara Kakiris, *Analex Corporation/NASA Glenn, LTID* Vincent Reich, *RS Information Systems, Inc./NASA Glenn, LTID*
Track 5	David Lowenfeld, *BTAS, Inc./NASA Glenn* Terri Rodgers, *NASA Glenn*
Tracks 6 and 7	David Lowenfeld, *BTAS, Inc./NASA Glenn*
Track 8	Bill Fletcher, *RS Information Systems, Inc./NASA Glenn, LTID*
Tracks 10 and 11	Gail Perusek, *NASA Glenn* Matt Murray, *RS Information Systems, Inc./NASA Glenn, LTID*

*Refer to credits in ***Auditory Demonstrations II*** liner notes for detailed studio credits.
Refer to credits in ***Auditory Demonstrations II* liner notes for voice talent credits.

Imagery:	Audiometric booth—track 7, *courtesy of Eckel Industries, Inc.* Cleveland, Ohio City Hall rotunda—track 7, *courtesy of city of Cleveland, OH*
Music:	Track 19, *courtesy of Cleveland Institute of Music, Cleveland, OH*

References

[1]Information about NC and STC curves:
Cyril M. Harris, ed., **Noise Control in Buildings**, McGraw-Hill, Inc., New York, NY, 1994.

[2]Hearing loss predictions taken from:
ISO 1999–1990. "Acoustics—Determination of occupational noise exposure and estimation of noise-induced hearing impairment," International Organization for Standardization, Case Postale 56, CH–1211 Geneve 20, Switzerland. http://www.iso.org/iso/en/ISOOnline.frontpage

[3]Information on NRR of hearing protectors:
Berger, EH, Royster, LH, Driscoll, DP, Royster, JD, and Layne, M (2000). **The Noise Manual (Fifth Edition).** American Industrial Hygiene Association, Fairfax, VA.

Annotated Track Listing

(Numbers in parentheses are the track numbers of the corresponding audio track on the ***Auditory Demonstrations II*** CD.)

1 (1). **Calibration signal: "Sundial"**—Dialog of normal running speech; may be used for initial volume setting using listener comfort level. *(Audio only)*

2 (3). **Calibration Tone**: 70 dB band of noise, $^1/_3$-octave width, centered at 1 kHz (applies to tracks 3 to 8). *(Audio only)*

3 (5). **International Space Station (ISS) Scripted Speech Versus Increasing NC Sequence.** Simulation of actual audio recorded during flight operations on the International Space Station. Speech (58 dBA) versus artificial background noise (NC 40 increasing to NC 60; see Appendix A). Each beep denotes an increase of five NC points. Speech intelligibility should become increasingly difficult above NC 50.

4 (13). **Restaurant Conversation Versus Typical Environment With Progressive Hearing Loss.** Speech (66 dBA) versus typical restaurant sound (67 dBA), filtered to simulate 40 years of progressive noise-induced hearing loss (see appendix B). Each beep denotes an additional 5-year increment of hearing loss. Increasing hearing loss reduces speech intelligibility, especially beyond 25 years.

5 (16). **Lecture Hall Crosstalk With Increasing Partition Performance.** Speech (63 dBA) versus amplified rally in adjacent space (85 dBA filtered through a succession of partitions STC 20 through STC 60; see appendix C). Each beep denotes an increase in partition performance of five STC points. A partition of STC 40 or more is typically sufficient to eliminate interference with speech intelligibility, but the crosstalk is still audible up through STC 55. Intentional pauses in speech allow the listener to attend to the level of crosstalk.

6 (17). **Lecture Hall Speech Versus Increasing NC Sequence.** Speech (63 dBA) versus artificial background (NC 30 increasing to NC 50, see appendix A). Each beep denotes an increase of five NC points in the background noise. The lecture hall environment should ideally be NC 30 (or less). Notice that although speech is still intelligible at higher levels, the noisier environments are inappropriately loud.

7 (18). **Lecture Hall Speech Versus Increasing Reverberation Time Sequence.** Speech (63 dBA) versus artificial reverberation. The reverberation time increases from 0.0 to 4.0 seconds. The listener is located in the reverberant field at some distance from the speaker. The shorter reverberation times add significant coloration to the sound but do not affect speech intelligibility. Each beep denotes transition to the next level of reverberation. The sequence of reverberation times, in seconds, is 0.000, 0.125, 0.250, 0.500, 0.875, 1.250, 2.000, 2.700, and 4.000.

8 (21). **Classroom Instruction Versus Interior Noise.** Speech (64 dBA) versus various internal building noises. Initially, the speech is subjected to a reverberation time of 1.25 seconds and must compete with HVAC noise (50 dBA, NC 45) and a nearby basketball practice (73 dBA) filtered to simulate a poorly performing door to the corridor (STC 20). After 11 seconds, the basketball practice noise is filtered to simulate substitution of an improved STC 40 door. Beginning at 22 seconds, the HVAC noise is reduced 3 times in 5 dB increments to 35 dBA (NC 30). It is interesting to note that the basketball practice is once again audible, although barely, because the masking of the HVAC noise has been removed. At about 45 seconds, the reverberation is reduced to 0.50 seconds. The final environment just conforms to ANSI S12.60 guidelines for classrooms. (ANSI S12.60–2002 "Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools," Acoustical Society of America, Standards Secretariat, 35 Pinelawn Road, Suite 114 E, Melville, New York 11747–3177, http://asa.aip.org)

9 (22). **Calibration Tone**: 70 dB band of noise, 1/3-octave width, centered at 1 kHz. Applies to tracks 10 and 11. *(Audio only)*

10 (27). **Industrial Conversation Versus Typical Industrial Environment With Progressive Hearing Loss.** Speech (75 dBA) versus a typical industrial environment (74 to 77 dBA) filtered to simulate 40 years of progressive noise-induced hearing loss (see appendix B) in 5-year increments. Each beep denotes an additional 5-year increment of hearing loss. Increasing hearing loss reduces speech intelligibility, especially beyond 25 years.

11 (28). **Industrial Conversation Versus Typical Industrial Environment With Progressively Stronger Hearing Protectors.** Speech (75 dBA) versus a typical industrial environment (74 to 77 dBA) filtered to simulate use of hearing protectors. The demonstration includes initial and final unfiltered segments and filters introduced at regular intervals (denoted by a beep) to simulate use of various popular hearing protectors (NRR 12 to 29; see appendix D).

12 – 21 (35-44). **Music "Meltdowns" (Music Listening With Progressive Hearing Loss)** Musical selections are filtered to simulate 40 years of progressive noise-induced hearing loss (see appendix B) in 5-year increments, with each 5-year increment indicated by a beep. At the end of the selection, the filtering is removed.

The music is still audible and for the most part intelligible, although certainly far less enjoyable. The musical source material for each demonstration is as follows:

12 (35). **Pop: "*Up and Away,*"**
Killer Tracks #147, Track 1

13 (36). **Rap: "It's a Groove Thing,"**
KOKA #2182, Track 2

14 (37). **Rock: "Sweatin' Mass,"**
XCD #068, Track 2

15 (38). **Country: "Like I Feel Right Now,"**
KOKA 2163, Track 5

16 (39). **Latin: "Perrito Caliente,"**
APM Best-20, Track 11

17 (40). **Techno: "Sweat Shop,"**
XCD 049, Track 7

18 (41). **Jazz: "As Good as it Gets,"**
XCD 023, Track 3

19 (42). **Classical: Symphony in A Major, No. 4, Op. 90 "*Italian*,"** by Felix Mendelssohn, recorded at Kulas Hall, Cleveland Institute of Music (CIM), October 17, 2001. Performed by the CIM Orchestra, Carl Topilow, conductor, Alan Bise recording engineer. Thanks to Paul Blakemore for help with this track.

20 (43). **Big Band: "Twilight Time,"**
KOKA #2060, Track 1

21 (44). **Swing: "Gypsy Rag,"**
KOKA #2121, Track 1
The animated video demonstrations on this CD may not be incorporated in whole or in part into

Appendix A:
Artificial Background Noise: Noise Criterion (NC) Curves

NC curve	Octave band sound pressure level, dB							
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
NC 15	47	36	29	22	17	14	12	11
NC 20	51	40	33	26	22	19	17	16
NC 25	54	44	37	31	27	24	22	21
NC 30	57	48	41	35	31	29	28	27
NC 35	60	52	45	40	36	34	33	32
NC 40	64	56	50	45	41	39	38	37
NC 45	67	60	54	49	46	44	43	42
NC 50	71	64	58	54	51	49	48	47
NC 55	74	67	62	58	56	54	53	52
NC 60	77	71	67	63	61	59	58	57
NC 65	80	75	71	68	66	64	63	62

Appendix B:
Progressive Sensorineural Hearing Loss*

Exposure duration, years	Hearing Level (HL), dB					
	500 Hz	1000 Hz	2000 Hz	3000 Hz	4000 Hz	6000 Hz
5	0	0	0	5	8	5
10	1	1	3	10	13	9
15	1	1	5	12	15	12
20	2	2	7	14	18	15
25	3	3	9	17	22	19
30	4	4	12	20	25	23
35	5	6	14	23	29	28
40	6	7	17	27	34	34

*50th percentile, average male/female, 90 dBA exposure, 8 hours per day, per ISO 1999.

Appendix C:
Building Components, Insertion Loss

Sound Transmission Class	Octave band Insertion Loss (IL), dB							
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
STC 20	6	10	18	20	20	20	19	20
STC 25	5	12	21	25	26	26	25	26
STC 30	7	12	21	27	30	31	29	31
STC 35	11	18	26	34	36	36	36	37
STC 40	16	18	26	37	46	44	43	54
STC 45	18	23	35	44	51	48	44	56
STC 50	19	27	38	48	54	53	52	64
STC 55	18	29	45	55	57	59	57	66
STC 60	22	35	49	60	61	63	62	71

STC 20: 89 percent of area is wall of 1/2-inch gypsum board both sides on nominal 2 by 4 studs on 16-inch centers, 10 percent of area is solid core wood door, no seals, 1 percent of area leaks

STC 25: 90 percent of area is wall of 1/2-inch gypsum board both sides on nominal 2 by 4 studs on 16-inch centers, 10 percent of area is solid core wood door, no seals, 0.2 percent of area leaks

STC 30: 66 percent of area is wall of 1/2-inch gypsum board both sides on nominal 2 by 4 studs on 16-inch centers, 34 percent of area is 1/8-inch glass, 0.05 percent of area leaks

STC 35: Two layers 1/2-inch gypsum board on one side, 1 layer 1/2-inch gypsum board on the other, 2 1/2-inch steel studs, 0.02 percent leaks

STC 40: Two layers 1/2-inch gypsum board on one side, 1 layer 1/2-inch gypsum board on the other, 2 1/2-inch steel studs, no leaks

STC 45: Two layers 1/2-inch gypsum board on one side, 1 layer 1/2-inch gypsum board on the other, 3 5/8-inch steel studs on 24-inch centers, no leaks

STC 50: Two layers 1/2-inch gypsum board each side of 2 1/2-inch steel studs, no leaks

STC 55: Two layers 1/2-inch gypsum board, resilient channels, 3 5/8-inch steel studs, 3-inch mineral fiber cavity insulation, 1 layer 1/2-inch gypsum board, no leaks

STC 60: Two layers 1/2-inch gypsum board, resilient channels, 3 5/8-inch steel studs, 3-inch mineral fiber cavity insulation, 2 layers 1/2-inch gypsum board, no leaks

Appendix D:
Hearing Protectors, Attenuation Data*

Noise Reduction Rating	Octave band attenuation, dB								
	125	250	500	1000	2000	3150	4000	6300	8000
NRR 12	15	15	17	19	23	23	20	22	25
NRR 16	12	17	24	23	24	27	25	23	26
NRR 20	12	16	27	32	33	35	38	42	42
NRR 25	17	22	34	40	35	36	38	38	40
NRR 29	37	41	45	44	36	42	43	46	47

*http://www.e-a-r.com/e%2Da%2Dr.com/default2.cfm